LDES NATIONAL CONSORTIUM

LDES National Consortium Workshop

Advanced Modeling for Investment Planning

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End-User Microgrid Modeling to Support LDES Valuation

Thank you to the LDES Consortium!

- Mindset / perspective of this presentation
- Using solar and Lithium-ion BESS as the baseline resource
- Hourly modeling of typical year solar (not extreme) versus actual load curve
- Model has been performed dozens of times in past couple of years
- With enough solar to attain net zero electricity and a 4-hour BESS, greater than 20% gaps in meeting load still arise
- Can overbuild solar and BESS by 2x, doubling costs, and still have a 5% gap
- Conclusion: Under carbon free electricity (CFE) mindset, economics and valuation of LDES are not necessarily reflective of today's economics but rather the future-case at-scale CFE scenario.

Modeling, LDES Valuation vs Overbuilding

- This microgrid hourly model allows us to perform multiple simulations efficiently
  - Net zero approach: 2 hr BESS, 23% of hourly loads not met, 4 hr BESS, 19% of hourly loads not met
  - Overbuild solar by 2x: 2 hr BESS, 5% of hourly loads not met, 2% of hourly loads not met
  - Overbuilding solar has cost impact of doubling both the solar and BESS costs yet does not meet all hourly needs
  - Result: Pressure to seek out dispatchable resources in microgrid such as diesel / natural gas engines, turbines, hydrogen, etc.

PV Size (MWdc)	**CLPE Balancing Metric**		**BESS Size (MWh)**	**CLPE Balancing Metric**	**Planning Cost**	**Microgrid Unmet Load, %**	**Notes**
				PV / BESS only modeling			
0.26	$ 2.36		1.04	$ 4.08	$ 1,404,000	18.9%	Assumption for Net Zero Electricity for Area, 4hr BESS
0.260	$ 2.39		0.78	$ 3.15	$ 1,248,000	19.9%	Assumption for Net Zero Electricity for Area, 3hr BESS
0.260	$ 2.50		0.52	$ 2.29	$ 1,092,000	23.2%	Assumption for Net Zero Electricity for Area, 2hr BESS
0.260	$ 2.33		1.56	$ 6.00	$ 1,716,000	18.1%	Assumption for Net Zero Electricity for Area, 6hr BESS
0.520	$ 3.84		3.12	$ 9.04	$ 3,432,000	0.8%	Double net zero electricity. Modeling to reduce microgrid unmet load to less than 1% of expected conditions. 6 hr BESS
0.520	$ 3.89		2.08	$ 6.16	$ 2,808,000	2.0%	Double net zero electricity. 4 hr BESS
0.520	$ 4.01		1.04	$ 3.23	$ 2,184,000	4.4%	Double net zero electricity. 2 hr BESS
0.780	$ 5.76		3.12	$ 9.25	$ 4,212,000	0.3%	Triple net zero electricity. 4 hr BESS
0.780	$ 5.84		1.56	$ 4.71	$ 3,276,000	1.2%	Triple net zero electricity. 2 hr BESS
1.040	$ 7.74		2.08	$ 6.28	$ 4,368,000	0.2%	Quadruple net zero electricity. 2 hr BESS
1.040	$ 7.67		4.16	$ 12.50	$ 5,616,000	0.0%	Quadruple net zero electricity. 4 hr BESS

Investment Planning Through Advanced Modeling

- **Why Modeling is Critical**
  - Forecasting future energy needs and storage requirements.
  - Identifying cost-effective and efficient storage solutions.
  - Risk assessment and mitigation strategies.
- **Key Modeling Approaches**
  - Techno-Economic Modeling
    - Cost analysis (CAPEX, OPEX).
    - Return on Investment (ROI) calculations.
  - Scenario Analysis
    - Best-case, worst-case, and most likely scenarios.
    - Sensitivity analysis for different variables (e.g., energy prices, technology advancements).
  - Optimization Modeling
    - Optimal sizing and placement of storage systems.
    - Integration with existing infrastructure.

Investment Planning Through Advanced Modeling (cont.)

- **Stochastic Modeling**
  - Incorporates randomness and uncertainty in variables (e.g., energy prices, market demand). Uses probability distributions to forecast a range of possible outcomes. Enhances risk management by preparing for multiple scenarios.
- **Monte Carlo Simulations**
  - Uses repeated random sampling to simulate a wide range of scenarios. Helps in understanding the impact of risk and uncertainty on investment decisions. Produces a range of possible outcomes.
- **Real Options Analysis**
  - Evaluates investment opportunities as options that can be exercised, delayed, or abandoned. Considers the value of flexibility; useful for scenarios with high uncertainty and rapid technological advancements.
- **Integration with Financial Models**
  - Discounted Cash Flow (DCF) Analysis
    - Projects future cash flows and discounts them to present value to assess the attractiveness of an investment. Integrates with stochastic models to account for uncertainties in cash flow projections.
  - Scenario-Based Valuation
    - Combines financial modeling with scenarios (e.g., regulatory changes, technology costs). Provides a range of valuation outcomes under different potential futures. Helps address investor uncertainty.

Investment Planning Through Advanced Modeling (cont.)

- **Visualization Tools**
  - Heat Maps
    - Visualizes data to show areas of high and low expected returns. Useful for geographic or asset-type investment analysis.
  - Sensitivity Analysis Charts
    - Demonstrates how changes in key assumptions (e.g., energy prices, costs) impact investment outcomes. Helps identify the most sensitive variables and focus risk mitigation efforts.
- **Advantages of Advanced Modeling**
  - Improved Decision Making
    - Provides a deeper understanding of risks and potential returns. Helps in the transparent and justifiable decision-making process.
  - Enhanced Risk Management
    - Identifies and quantifies potential risks more effectively. Allows for better preparation and response strategies.
  - Optimized Investment Strategies
    - Identifies the most efficient allocation of resources for maximizing returns. Supports dynamic and flexible investment planning.

Discussion Questions

- What are the key challenges we need to address in a more optimal manner when attempting to level the analytical playing field for LDES and how do we address them?
  - Future climate impacts
  - Broader range of plausible outcomes, addressing risk and extreme events
  - Capturing more days in simulations and addressing computational complexity
  - Improving our understanding of LDES performance
  - Others…
- Are their any unique differences related to LDES versus standard BESS solutions?
- What are the top three techniques or modeling approaches we should suggest to the industry?

SUPPORTING SLIDES

EIA Data for Average Consumer Costs

- The EIA presents the average consumer in Connecticut, Massachusetts, Rhode Island, California, Alaska, and Hawaii paid more than $0.20 per kWh in 2021.
- By July 2023, the list had grown to Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New York, California, Alaska, and Hawaii.
- Most expensive 9 states and least expensive 10 states shown.

State	Average Price (cents/kWh)
Hawaii	43.03
Massachusetts	25.97
California	25.84
New Hampshire	25.46
Connecticut	24.61
Rhode Island	23.21
Alaska	23.10
Maine	22.44
New York	22.08
Vermont	19.93
Missouri	11.74
North Carolina	11.62
Oregon	11.42
Montana	11.33
Wyoming	11.09
North Dakota	10.92
Utah	10.84
Nebraska	10.79
Idaho	10.37
Washington	10.26

Example Costs for Approx. 10-15 MW BESS

- Assumption made on this project that at scale, total costs including grid connection, site prep, microgrid controller, fencing, etc in the neighborhood of $1,000 / kWh
- Often BESS cost estimating can be quite a bit lower with the lowest reflecting the cells only and around $600 / kWh for the BESS.
- For smaller 1-20 MW systems, can easily see $1,000-2,500 / kWh depending on site needs and infrastructure.

1. COMPONENT	FY 2024 ENERGY RESILIENCE AND CONSERVATION MILITARY CONSTRUCTION PROJECT DATA	2. Date
Defense Wide – USSF		March 2023

3. INSTALLATION AND LOCATION	4. PROJECT TITLE:
Vandenberg Space Force Base Vandenberg Main Base Site #1 California	Microgrid with Backup Power

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)
0904903D	813231	XUMU212934	57,000

9. COST ESTIMATES

Item	U/M	Quantity	Unit Cost	Cost ($000)
PRIMARY FACILITIES				**43,440**
Electric Substation (CC 813231)	KV	12	314,167	(3,770)
Battery Energy Storage System (BESS)	KWH	52,000	575	(29,900)
Microgrid Control System (MCS)	LS	-	-	(9,270)
Cybersecurity	LS	-	-	(500)
SUPPORTING FACILITIES				**1,410**
Site Improvements	LS	-	-	(1,410)
SUBTOTAL				**44,850**
CONTINGENCY				6,728
TOTAL CONTRACT COST				**51,578**
SUPERVISION, INSPECTION & OVERHEAD (6.5%)				3,353
DESIGN/BUILD – DESIGN COST (4%)				2,063
TOTAL REQUEST				56,993
TOTAL REQUEST (ROUNDED)				**57,000**
OTHER APPROPRIATIONS OR FUNDING SOURCES (NON ADD)				0

Example Costs for Less than 1 MW System

- Cost of $18 million for less than 1 MW system with natural gas recip engines providing backup resiliency for solar and BESS.

1. COMPONENT Defense Wide - Army/Active	FY 2024 ENERGY RESILIENCE AND CONSERVATION MILITARY CONSTRUCTION PROJECT DATA	2. Date March 2023

3. INSTALLATION AND LOCATION	4. PROJECT TITLE:
Fort Hood Texas	Microgrid and Backup Power

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)
0904903D	81122	99288	18,250

9. COST ESTIMATES

Item	U/M	Quantity	Unit Cost	Cost ($000)
PRIMARY FACILITIES				**12,500**
Natural Gas Reciprocating Internal Combustion Engine (RICE) Generators (CC81117)	KW	500	1,820	(910)
Solar Photovoltaic Array (CC81122)	KW	150	11,867	(1,780)
Energy Storage System (ESS) (CC81150)	KW	4,000	805	(3,220)
Microgrid Controller/Supervisory control and data acquisition (SCADA)	LS	--	--	(500)
Cybersecurity	LS	--	--	(250)
Environmental and Air Permitting	LS	--	--	(230)
Commissioning	LS	--	--	(3,400)
Switchgear	LS	--	--	(1,000)
Energy Storage System Switchgear	LS	--	--	(690)
Conductors	LS	--	--	(400)
Interconnection Agreement Fee	LS	--	--	(110)
Building Information Systems	LS	--	--	(10)
SUPPORTING FACILITIES				**2,230**
Electric Service	LS	--	--	(1,030)
Water, Sewer, Gas	LS	--	--	(210)
Site Improvements	LS	--	--	(790)
Information Systems	LS	--	--	(100)
Sound Reduction	LS	--	--	(100)
PRIVATIZED UTILITY CONNECTION AND SERVICE FEE				160
SUBTOTAL				**14,890**
CONTINGENCY				2,234
TOTAL CONTRACT COST				**17,124**
SUPERVISION, INSPECTION & OVERHEAD (6.5%)				1,113
TOTAL REQUEST				18,237
TOTAL REQUEST (ROUNDED)				**18,250**